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# The Design of an Interactive and Dynamic Representation of the Firm

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## Abstract

Interpretation and audit of financial information is a significant undertaking that must rest on a fuller understanding of the firm and its operations. A pictorial representation of firm activity offers promise for supporting this requirement. After reviewing the literature related to visualizations, we describe the design of an interactive animated version of the cycle model. Business Animator assists users in developing an intuitive sense about the cycle model itself, while exploring and visualizing how firms at various stages of growth, sustenance, and decay are affected by specific operating decisions. Principles and findings from the accounting and information systems literatures were used to drive the design of the representation and software used to control it. This resulting system adds depth to traditional accounting representations by conveying information about the momentum of the firm's activities, the rate of change at which various activities are occurring. The animation facilitates identification of backlogs or breaks in operating processes, thus increasing understanding of the firm's financial health.

**Keywords:** Animation, Visualization, Information Representation, Accounting Information Systems, Decision Making

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## Introduction

Little has changed in the graphics we use to represent key management data since William Playfair published his *Commercial and Political Atlas* in 1786. Meanwhile many areas of science and engineering have seen interactive computer graphics transform the way they explore and present data. Whether it is a weather pattern or a molecule, a tsunami or an as yet unbuilt building, computer graphics are being used both to explore and to explain complex systems. In this paper, we describe the design of Business Animator, a computer-based interactive animation for representing many dimension of an organization's financial and operational performance.

## Research on Financial and Accounting Representations

Since the earliest recorded history, humans have developed accounting systems for recording their transactions with one another. The double entry system in wide use today was published by Fra Luca Pacioli in 1494. The financial statements that are produced by this system have been refined over the centuries and formalized by rules and regulations, in the United States captured by the term U. S. GAAP (generally accepted accounting principles). Yet understanding how the financial statements represent a firm and its operations is an ongoing challenge for the financial world. Mandated financial statements require agreement upon an accepted set of standards, definitions, and rules, but U.S. GAAP acknowledges the complexity and multiplicity of forms of businesses by allowing options within accepted methods of both measurement and reporting. Thus, interpreting the resulting financial statements of any firm is a significant undertaking that must rest on a fuller understanding of the firm and its operations. Similarly, the interpretation of internal financial information presents challenges for both managers and auditors. Managers need to be able to identify potential operational problems as soon as possible. Auditors (internal and external) need to be able to identify weaknesses in underlying data as well as the reports generated.

Mathematical tools have been widely used for financial analysis at both the internal and external levels. Perhaps the most common tool is ratio analysis, the computation of ratios based on some underlying financial data to allow relative comparisons of one firm to another or a firm to itself over time. Ratios provide useful information, but interpretation is neither automatic nor instantly accessible. Analysts and researchers have frequently attempted to ease ratio interpretation by some sort of presentation other than columns of numbers. Charts, graphs and even faces have been used in attempts to improve the interpretation of financial statement information.

Chernoff (1973) posited the use of readily interpreted faces to represent multidimensional points in financial data. Huff *et al.* (1981) applied this technique to determine whether it could be used to detect potential business failures. Their results were consistent with the multi-dimensional approach being informative, but their sample size was inadequate to provide statistical tests. Ferris and Tennant (1982) proposed the use of the Chernoff face to help with internal audit and analytical review functions, seeing this tool as providing a quick signal of possible problems. Scherr and Wilson (1985) compared three methods for estimating bond ratings--ratio tables, Chernoff faces, and multiple discriminant analysis. They found that

statistical discriminant analysis outperformed the other methods. Other approaches to visualizing accounting data are discussed in a later section.

Another stream of literature has focused on what data might be missing in the traditional financial information being produced. Ijiri (1982, 1986) posited and developed the notion of triple-entry bookkeeping as a way to address a weakness in the current system, its inability to represent rate of change in financial variables and the force behind those rates. He proposed measuring dollars per time period, or “momentum,” to account for rates of changes in the various accounts, with the term “force” used to identify the factors that affect rates, suggesting that use of these sorts of measures would help managers to focus their attention more productively. Blommaert (2001) tested the usefulness of momentum and force information, finding that these data facilitate decision making by laboratory subjects.

In this paper we integrate and extend these various streams of theoretical and empirical research around the problems of representation. We use concepts from these different theoretical areas to create a more complete picture of the firm than can be conveyed in a single face or static graph, while at the same time creating a more concise representation of multiple dimensions than would be available in an array of charts and graphs. Our design addresses important results related to the psychology of visual representation and takes advantage of technological developments to exploit the power of animation. Those are the subjects of the next several sections.

### **The Psychology of Visual Representation**

A basic principle of distributed cognition is that a cognitive task includes both internal and external representations, which together contain the abstract structure of the task. In order to perform a cognitive task, such as making a business judgment or decision, people need to process information distributed across the internal mind and the external environment.

In a study using the Tower of Hanoi problem, Zhang and Norman (1994) found support for the theory. In exploring the nature of external representations, they determined that such representations 1) can serve as memory aids, 2) provide information that can be perceived and used directly without being interpreted and formulated explicitly, 3) anchor and structure cognitive behavior, and 4) change the nature of a task. According to Hutchins (1995), the nature of the external representations available to them greatly influences an individual's cognitive performance. So, in thinking through the design of an abstract representation to assist human decision makers in understanding complexities of an organization's financial and operational performance, it seems important to understand both the internal and the external representations. The external representation is under our control, in that it is the object of our design activity. Some issues related to the internal representations will be addressed in the remainder of this section.

Internal representation is one of the earliest theoretical constructs of cognitive science. It is often referred to as the mental representation. Contemporary cognitive scientists, particularly as contrasted with behavioral psychologists, argue that the internal representations stored in our minds cause and explain much of behavior. Human cognition has become specialized for dealing with both language and nonverbal objects simultaneously. Researchers have attempted to build models to explain how internal representations achieve this from different theoretical perspectives. Two principal theories have emerged. Propositional theory argues that information of all kinds is memorized in the same way, and that a causal map connects our memories. Imagery theory posits that people store and process images and words in different ways.

Based on imagery research, dual coding theory suggests that memory consists of two separate and distinct mental representation systems—verbal and nonverbal. Accordingly, cognition is served by two modality-specific systems that function differently in representing and processing information concerning nonverbal objects and language. The basic representational units of these two systems are logogens (word generators) and imagens (image generators). There are three connections in the resulting cognition system. Representational processing is the relatively direct activation of logogens by linguistic stimuli and imagens by nonverbal stimuli; referential processing is the cross-system activation required in putting images to words and names to objects, and associative processing is the activation of representations within either system, accounting for the spread of association among words or images (Paivio, 1991). Representational processing is necessary for any cognitive tasks, but it does not necessarily have a one-to-one correspondence with referential processing.

Rieber (1994) concluded that the main contributions of dual coding are that information is much easier to retain and retrieve because of the availability of two mental representations and that recalling information contained in the visual system is much faster than recalling information in the verbal system because the visual system accesses information through synchronous processing, as opposed to sequential access in the verbal system. Further, people process and recall pictures more fully than words and sentences, which results in more propositional information and more durable traces between the propositions stored in long-term memory.

Propositional theory offers an alternative view of memory that argues against the dual coding process. It argues that people remember a picture's meaning rather than its visual attributes (Bower, Karlin and Dueck, 1975; Driscoll, 1994). Therefore all information can be stored in long-term memory in semantic or verbal forms structured as a propositional (if-then) network. A second type of coding is not necessary, and in the interests of parsimony, is not posited. Although the propositional theory agrees to the existence of visual processing in short-term memory, it disputes the superiority of visual over verbal representations (Rieber, 1994).

### **Linking Internal and External Representations**

Whatever external representations we create will have to link to the internal representations that people produce. Indeed, a good external representation will be one that links naturally to the internal representations that people are capable of forming, thereby supporting their overall cognitive processes.

Scaife and Rogers (1996) identified three characteristics that can be used to explain the connection between internal and external representations. Computational offloading refers to the extent to which the external representation reduces the amount of cognitive effort required to solve a problem. Re-representation refers to how different external representations with the same abstract structure can make solving problems easier or more difficult. Finally, graphical constraining refers to how the elements used in various representations constrain the inferences that can be made about the world being represented.

Computational offloading is one of the arguments made for visual computing (Friedhoff and Peercy, 2000). Visualization can be defined as the substitution of preconscious visual competencies and machine computation for conscious thinking (Gershon *et al.*, 1994). The term preconscious refers to the hardwired highly parallel processes that handle the initial stages of analysis of the retinal patterns. It encompasses all of the visual processes that do not seem to be manifestly consciously mediated. Preconscious processing is parallel, fast, automatic, and

indefatigable. Conscious processing is serial, flexible, continuous and required for sophisticated analyses. Consequently, preconscious processing carries less cognitive load than conscious processing.

This theory argues that “visualization is useful whenever the impact of an independent variable on a dependent variable can be perceived preconsciously (Friedhoff and Peercy, 2000, p. 121).” In a successful visualization, conscious thinking can be directed at probing the relationship between independent and dependent variables without distraction. Color, size, contrast, tilt, curvature, line ends, the direction of lighting, movement, and stereoscopic depth are properties that affect the early preconscious stages of visual processing. We can facilitate the effective use of visualization by increasing the amount of preconscious processing. A basic way to do this is to improve the visibility of the information embedded in the data (Domik, 1999). Animated visualization can take advantage of the sensitivity of the visual system to dynamic changes in various aspects of the data in order to engage preconscious processing.

In the current context both re-representation and graphical constraining are addressed in part by cognitive fit theory, which has attempted to build a connection between internal representations and external representations from the system’s view (Vessey, 1991). Cognitive fit separates tasks as spatial or symbolic, based on the type of information used to reach the solution, and classifies representations into similar dimensions, such as graphical representations that emphasize spatial information and tabular representations that emphasize symbolic information. Cognitive fit theory argues that the effectiveness of problem solving is a function of the relationship between the problem solving task and the problem representation so that a fit of representation and task type will result in both quicker and more accurate problem solving. This finding has been supported and extended in empirical studies (Dennis and Carte, 1998; Dull and Tegarden, 1999; Lim and Benbasat, 2000; Umanath and Vessey, 1994; Vessey and Galletta, 1991). Cognitive fit theory, then, suggests that representations must be driven in part by the characteristics of the tasks to be supported.

### Verbal vs. Graphical Representations

The first issue we face is whether given our task (to induce understanding of the financial and operational activities in an organization over time), verbal or graphical representations be favored.

Tables and graphs are both commonly used to represent large data sets. Many studies have explored the features of these two representations and the conditions under which each is superior. The most influential findings are from the series of studies by Benbasat *et al.* (Benbasat and Dexter, 1985, 1986; Benbasat, Dexter, and Todd, 1986a; Benbasat *et al.*, 1986b). Their research examined the effects of graphs in managerial decision-making tasks comparing them to tabular representations. A well-known marketing problem—the Brand Manager’s Allocation Problem—was used. Participants could simulate up to 30 allocations to find the solution. Their studies concluded that graphical presentation was more useful in the search for the optimal solution, but tables were more useful in tasks that required determining exact numbers.

In an experiment by Carey and White (1991) forecasts were more accurate when subjects responded graphically than numerically. On the other hand, when Chan (2001) simulated a real business prediction task with business managers, prediction accuracy deteriorated under information overload, but the mode of presentation (graphs vs. tables) did not have a significant impact on prediction accuracy.



Smelcer and Carmel (1997) compared problem solving performance using tables and maps in geographic information systems. They found that maps generally produced faster problem solving than tables, especially for proximity and adjacency relationships. In another study of geographic tasks, Dennis and Carte (1998) extended cognitive fit theory and found that decision makers using a map-based presentation made faster and more accurate decisions when working on a geographic task in which there were adjacency relationships among the geographic areas. Decision makers using a map-based presentation made faster but less accurate decisions when working on a geographic task in which there were no relationships among the geographic areas.

In studies that are most closely related to the current research, Volmer (1992; 1993) compared graphical presentations of the financial ratios of the firm with numerical financial information, and concluded that visual presentation of graphical information not only produced time gains, but also were considered important in providing clear insight into the financial position of the firm, thus improving communication.

This literature provides a basis for optimism that a graphic representation will be useful, given our objective of developing an understanding of the dynamics of an organization through time.

### **The Power of Animation**

A second issue is whether the graphic representations employed should be dynamic.

There is a general belief that animations not only improve users' understanding, but also make interfaces easier and more enjoyable to use (Betrancourt and Tversky, 2000). This belief has been tested in many studies, although the results have not produced a consensus. In their review, Tversky, *et al.* (2002) argued that empirical studies had not provided strong evidence that animated graphics outperformed static graphics for several reasons. The most significant was the lack of equivalence in most studies between animated and static graphics in either content or procedures; that is, the animations used conveyed more information or involved interactivity. They concluded that conveying real-time changes and temporal-spatial reorientations seemed to be the most promising uses of animation due to people's natural cognitive correspondences based on the congruence principle.

Rieber was one of the earliest to explore using animation to facilitate learning. In Rieber (1990) three levels of visual elaboration (static graphics, animated graphics, and no graphics) were crossed with three levels of practice (behavioral, cognitive, and no practice). Behavioral practice consisted of traditional questioning, and cognitive practice consisted of a structured simulation. The visualization in the experiment was designed to explain Newton's laws of motion. Animated graphics were found superior to both static graphics and no graphics when practice was provided. The same experiment was conducted again in Rieber (1991), but with the focus changed to the effects of animated presentations on incidental learning. In an experiment involving 70 students static graphics were compared with animated graphics. The author found that students successfully extracted incidental information from animated graphics without risk to intentional learning, but were also more prone to developing a scientific misconception.

Rieber (1996) explored how users interact and learn during a computer-based simulation given animated graphical and textual feedback. In two experiments, the participants interacted with a simple simulation that modeled the relationship between acceleration and velocity. The experiment used a discovery-based approach, so the participants were not given formal instruction, but they had control over the acceleration of a simple screen object—a ball in a

game-like context. Three conditions were studied, each differing on how feedback of the ball's speed, direction, and position was represented: graphical feedback, textual feedback, and graphical plus textual feedback. Results showed that subjects got higher scores on the games when provided with animated graphical feedback than with textual feedback, although explicit understanding of the science principles did not depend on the way the feedback was represented.

Large, *et al.* (1994) did a series of experimental studies to explore the advantages of using animation in a multimedia learning environment. To compare students' ability to recall information and to draw inferences from it they set up three presentation conditions (printed text with illustrations, text-on-screen, and multimedia-text, still images, and animations) and a retrieval condition. Although animation provided a dramatic visual effect, its impact on learning appeared to be much more subtle. Multimedia enhanced comprehension but the extent to which this happened was determined by a variety of factors including the level of complexity of the information, the kind of information being conveyed, and the degree of integration among the various media. Multimedia had the greatest effect in the case of simple topics, and especially a simple procedural topic. In a follow-up study by Large and Beheshti (1995), four different media combinations (text only; text plus animation; text plus captions plus animation; and captions with animation) were used to test similar cognitive tasks on 71 children. The children in the text plus animation and captions group were more successful at identifying the major steps in the procedure and at enacting the procedure.

Large, Beheshti and Renaud (1996) investigated the role of animation in enhancing recall and comprehension of text. Four experimental conditions were adapted from the previous research, and three tasks including written recall, multiple choice questions, and problem-solving were used. Animation was found to improve significantly only the problem-solving task that involved the highest level of cognitive effort. In a summary, Large *et al.* (1996) suggested that animation could improve learning effectiveness only if it was designed carefully and integrated with content properly. In addition, several animation design factors, such as animation sequencing, text-animation linkages, and animation complexity, seemed to be crucial, but remain to be investigated.

Mayer and Anderson (1992) and Mayer and Sims (1994) extended dual coding theory to the multimedia learning context. Their model emphasized the learner's building of mental connections between visual and verbal representations. They argued that retention requires the construction of representational connections and that problem solving requires the construction of representational and referential connections. They also found that pictures (visuals) and words (verbal explanations) were most effective when they occurred contiguously in time or space, which they named the contiguity effect. They argued that the learner must build an internal verbal representation from the verbal information, an internal visual representation from the visual information, and referential connections between these representations for meaningful learning that supports problem-solving transfer.

Morrison and Vogel (1998) did an experiment to study the impact of animation on presentation persuasiveness. The results showed that the combined animation/transition visuals most enhanced presenter perception, while animation-only treatment appeared most effective in improving comprehension. The authors reasoned that animation emphasized important concepts on some visuals, thus giving the subjects a mental image that enabled them to recall the messages successfully.

Movement and interactivity have been addressed as two important attributes provided by animations. Gonzalez and Kasper (1997) proposed a framework to investigate the efficacy of

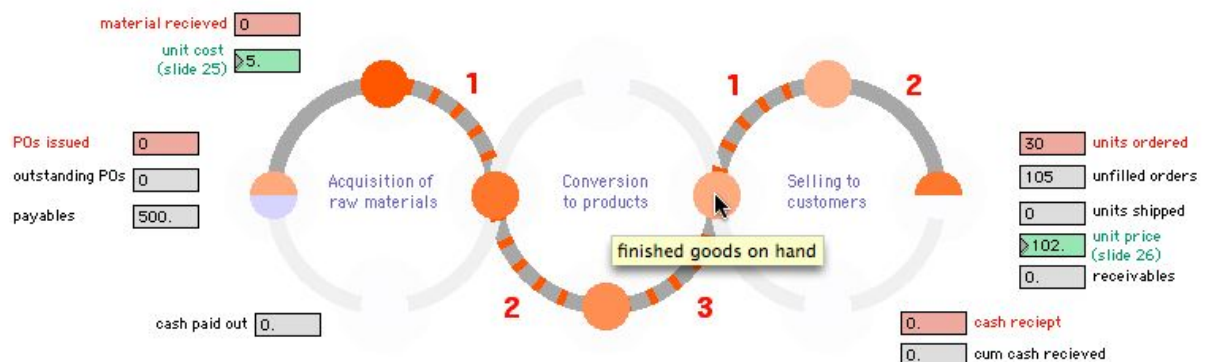


animation in user interfaces designed for decision support systems. In this framework, four properties were identified for animation: image abstraction (realistic-abstract), transition (gradual-abrupt, dissolving, fading, etc), alteration (texturing, coloration, etc.), and interactivity (manipulation, navigation). The authors tested the framework in a lab experiment with a 2 (abstraction) by 2 (transition) by 2 (interactivity) design. Two different tasks were involved—Home Directory and Bolt and Boat. The Home Directory task was to choose the best place to rent from a set of possible alternatives, and Bolt and Boat was to choose the alternative that best described the change in fluid level resulting from placing a bolt in a bucket of water. The authors found that the decision quality of subjects that used a parallel navigation technique in animation was significantly greater than that of those that used a sequential navigation interactivity technique, but the impact of abstraction and transition were unclear. For the Home Directory task, decision quality was significantly greater for subjects that used realistic as opposed to abstract images, but decision quality did not vary by transition effect. For the Bolt and Boat task, decision quality was significantly greater for subjects that used gradual as compared to abrupt transitions, but image abstraction had no effect on decision quality.

Since our visualization is for use with data that have a strong temporal character, and in an environment where there will be repeated use and learning, we have reason to anticipate that animation will be useful. Dual coding theory suggests that we should insure that information is provided in both graphic and verbal forms.

### The Cycle Model

Visual models of the firm's operating activity have been proposed as a way of helping managers and accountants understand the critical components of a firm's operating cycle. Boland (1983) proposed the cycle model, the most basic version of which presents the operations of a firm as three interacting cycles: an input cycle, a transformation or value-adding cycle, and an output cycle. A manufacturing firm provides the most accessible interpretation of these sets of activities. The model assumes an existing business with the ability to purchase raw materials on credit. In the input cycle, a company acquires raw materials from its suppliers. In the transformation cycle, value is added to the raw materials through the manufacturing process to create inventory to sell to customers. The output cycle represents the sale of the finished goods to the customers of the firm.

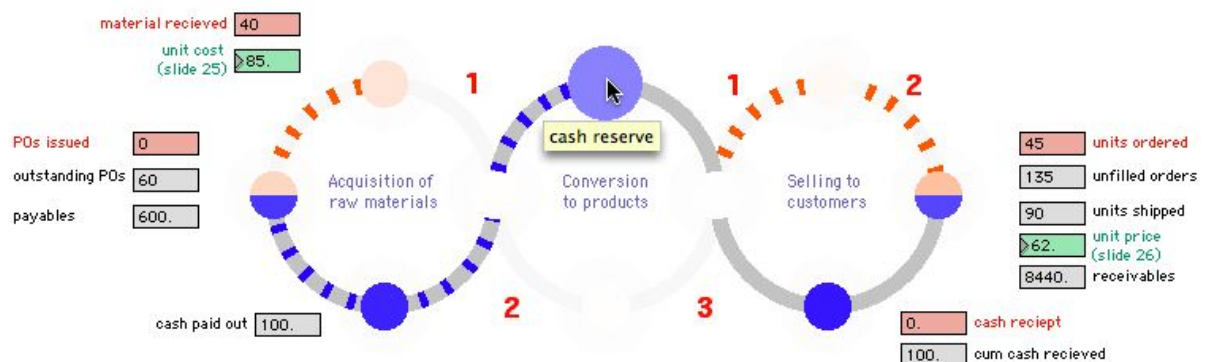


**Figure 1.** Material moves through seven moments from receipt to sale

The cycle model contains representations for the stocks and flows that characterize the movement of materials and monies through the organization. In each of the three cycles there are several moments and arcs connecting the moments. These can be used to represent ratio data that is often used to characterize a firm. Figure 1 shows the path that defines the movement of material. At the extreme left is a node that represents the firm issuing credit purchase orders to its suppliers for raw materials at agreed-upon prices. The size of nodes represents the capacity of that part of the enterprise; in this case how much material can be on order. The node's brightness represents how much is currently on order. This basic idea is used through the paths.

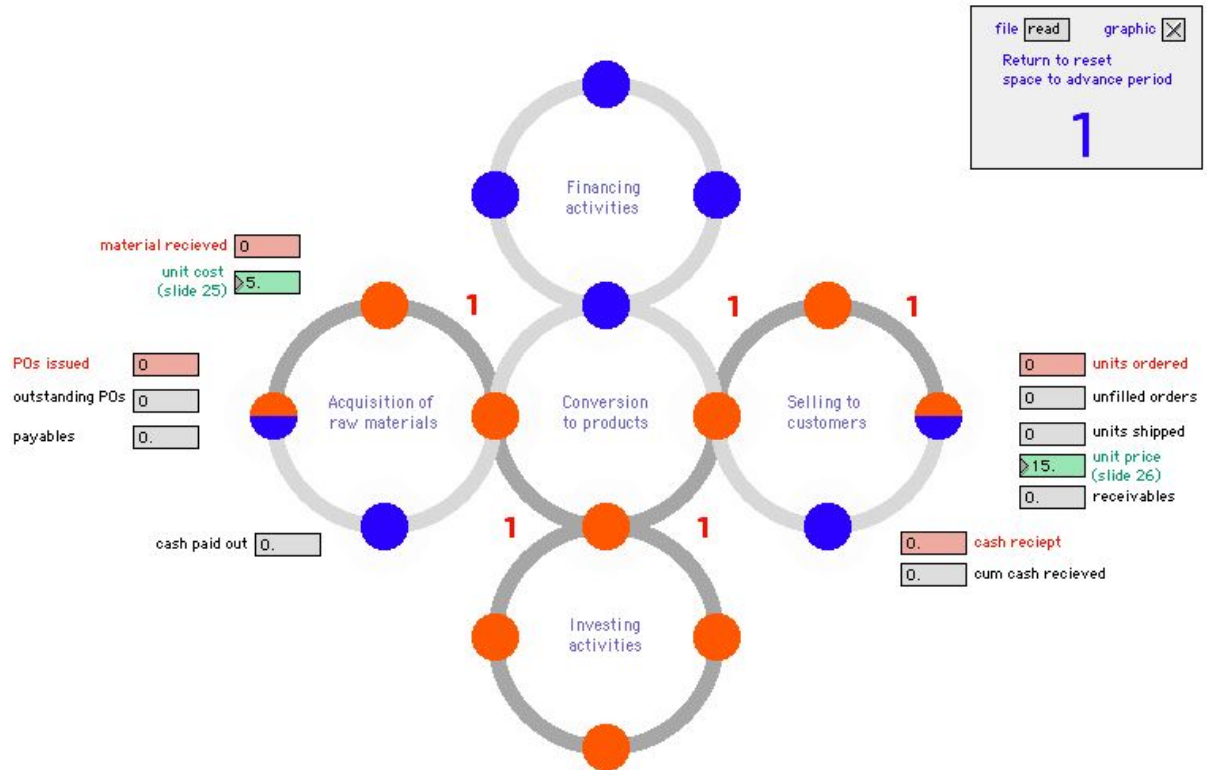
The next node along that path represents the delivery of raw materials. The connections between nodes vary in speed based on the time it takes for the system to make the necessary transformation. If things are moving rapidly through a part of the system this will be reflected by the relative rate at which that link moves. The amount of material moving is represented by the brightness of the link. From inbound logistics the material moves along the next arc into the middle cycle, which is where raw materials are transformed into finished goods. In the transformation cycle labor is applied to turn the raw materials into finished goods that are available for sale. Once transformed the goods are put into inventory and in the final cycle made available for sale.

Figure 2 illustrates the movement of cash. It moves from right to left; starting at the rightmost node with receivables. Cash is received from customers at the next node. Money moves to a cash reserve node at the top of the middle cycle and then to a cash out node at the bottom of the left one. Finally it is used to pay for materials received earlier.



**Figure 2.** Cash move from receipts at the right to payables at the left

This stylized representation, the operating cycle, represents the day-to-day operations of the firm. For a firm to be able to operate, however, requires capital investments in property, plant, and equipment and the funding to make those investments. We have assumed an existing firm with adequate resources for its current level of operations. The possibility of changing those levels of resources is added to the model by appending two additional cycles, an investing cycle and a financing cycle. In Figure 3 the investing cycle is placed at the bottom of the initial model and the financing cycle is placed at the top. These additions create links between the operations of the firm and how it creates or increases the structures and resources to allow those operations to occur.



**Figure 3.** The production model is augmented with a financing cycle and an investing cycle

The investing cycle incorporates decisions to acquire assets that support long-term operations. These include items typically referred to in accounting as capital investments, i.e., property, plant, and equipment, but also include research and development (R & D), and development of human capital. This placement acknowledges the fact that R & D and employee development are not day-to-day requirements of operating. Their inclusion in investments reflects the role of these expenditures in a firm's strategy and the creation of growth opportunities. A larger physical asset base allows the scale of operations to increase, growth in R & D leads to the creation of new products or processes, and investments in human capital increase knowledge and effectiveness within the firm's activities. The interaction with the operating cycle provides the opportunity for information exchange about resources needed to maintain or increase the level of operations.

As the scale of investments in this lower cycle determines the potential scale of day-to-day operations, activity in the upper, financing cycle reflects decisions about how to raise the money necessary to cover the firm's capital investments. In a corporation these long-term investments can be raised by issuing stock or by borrowing using debt contracts. In the healthy, steady state firm, the operating cycle should support itself. That is, the money collected from the sale of products to customers should be adequate to pay suppliers, as well as labor and other costs incurred in the transformation cycle. In this situation, monies raised from stock or debt issuance are directed toward maintaining or enhancing the capital asset base required for the operation. The interaction with the operating cycle provides the opportunity for information exchange about long-term funding requirements beyond what is being generated by operations.

The picture of the overall activities of the firm represented in Figure 3 should seem somewhat familiar to financial statement users since it conforms roughly to the structure of the cash flow statement and its labeled sections. Operating activities are generally associated with current assets and current liabilities, i.e., accounts receivable from customers, inventories, accounts payable to suppliers, and operating accruals. Financing activities are associated with long-term debt and stockholders' equity, that is, the sources of long-term capital investments. The representation of investing activities in the model departs from typical financial statements, which would include the expenditure for property, plant, and equipment and other long-term assets but would not include the investments in research and development and human capital development. With that caveat, this stylized representation illustrates the existence of flows currently presented in financial information produced by firms. However, in a static form it does not allow the user to measure characteristics of the flows occurring within the individual component cycles.

### Adding Dynamics to the Cycle Model

With the advent of more powerful and accessible computer animation, the cycle model can be adapted to provide a dynamic representation of the firm's activities. Business Animator utilizes control and display technologies developed for the real time music industry (Max from Cycling 74). Our goal is to provide a program through which managers and analysts, using sophisticated controllers (knobs, sliders, pedals, etc.) are able to develop an intuitive sense about the cycle model itself, while exploring and visualizing how firms at various stages of growth, sustenance, and decay are affected by specific operating, financing, and investing decisions. The animated version of the model incorporates a holistic vision of what characterizes the entire organization. The animation portrays temporality, allowing the theoretical construct momentum to be captured and depicted as the cycles change at differing rates.

The rules that govern transition and rates of change in a business are embedded within the financial outcomes, some of which are measurable by ratios that can be generated to help understand a period of operations. For example, the operating cycle's speed and efficiency are related to ratios such as the turnovers of inventories, accounts payable, and accounts receivable. These turnovers reflect how quickly and efficiently inventory is managed, turned into finished goods, and converted ultimately to cash to be repaid to suppliers and reinvested in the business.

As higher turnovers represent faster movement, they are related to the concept of momentum, characterized by the animation of the cycle model to provide greater analytical insights and more precise internal managerial or auditing signals. The animation of the full operating cycle actually illustrates three component, interactive cycles with different rates of change at different parts of operations. That is, in any firm it is likely that momentum is not some constant rate that applies to the overall structure, but rather is different in different parts of the firm and different parts of the cycles, as reflected in the differing turnover ratios created using the working capital accounts.

The user can determine starting points or baseline acceptable conditions for a particular firm, creating inputs commensurate with specified ratio relationships. The program then runs through specified numbers of cycles. The user can also interact with the program via sliders and knobs to change parameters for simulations. The animation, using movement and color, indicates whether the operation remains smooth or whether problems occur. The program both illustrates

the cycle flows over the periods, and provides color cues indicating satisfactory conditions or potential problems. Backups at nodes are indicated by both a slowdown in cycle movement and by gradually changing colors.

We have begun to explore how backlogs in either inventory flow or cash flow within operations appear when animated. Even these fairly simple controls allow us to illustrate such situations as suppliers delivering inventories quickly into a sluggish transformation process, leading to a lower turnover in work-in-process inventory compared to raw materials. Or both of those cycles may be functioning perfectly, but customer demand may not be adequate to turn over finished goods quickly enough to generate cash to pay operating bills. Or all of the inventory turnovers might be similar and in synchronization, but customer collection creates a bottleneck when accounts receivable turnover decreases. Utilizing the accounts receivable and inventory turnover ratio relationships of a large Fortune 100 firm as a base, we have created four contrasting data situations that would lead to differences in momentum at different points of the operating cycle: slow receivable turnover with fast inventory turnover, fast receivable turnover with slow inventory turnover, slow turnover in both, and fast turnover in both. These data are fed into the model via a simple text file, and the operating cycle runs for as many cycles as desired.

### Conclusion

The development and use of the tool described in this paper has the potential to significantly improve the understanding of the financial condition of a firm, both from an external and an internal perspective. The cycle model of firm activity can be applied to *ex post* financial information to aid in the interpretation of ratios. It can quickly highlight areas in which the firm's operations were not as efficient or as effective as possible. The model can also be applied *ex ante* as a planning tool to identify potential pitfalls in operations. This sort of simulation is greatly enhanced by the use of readily understandable knobs and sliders so that a user can quickly change inputs and observe the results. Growth plans and other strategic decisions can be evaluated. As with any tool, the cycle model will never be better than the data provided to it, so the input parameters must be carefully considered and measured. And empirical validation will be required before we are able to assert the conditions under which the tool provides useful insights. Nevertheless, it has the potential to aid in understanding financial data in a way not formerly available.

It is not uncommon to ask what use is made of academic research. In the case of the current development, we have been consumers of information systems and accounting research. We used research results to make many of the decisions about the design of Business Animator, both in terms of the features that should be represented and the visualization techniques that should be employed. We anticipate that Business Animator will in turn be used to examine questions raised in that research, thereby completing the hermeneutic circle.

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